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The original objective of this DURIP topic was to provide specialized sources and detectors for innovative spectroscopic studies, to provide data, knowledge, and insight in a broad variety of research areas of vital Air Force importance. While the specifics of how to do this were slightly changed from the original proposal, the end result is the same. We have gone a long way toward increasing the reliability and expanding the usefulness of this transient nonlinear spectroscopy system. In addition we are now obtaining some funding directly from Wright Patterson Air Force base for sensor protection research, which was one of the goals of setting up this spectrometer.

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Final Technical Report
on
DEPARTMENT OF DEFENSE UNIVERSITY
RESEARCH INSTRUMENTATION PROGRAM

NONLINEAR OPTICAL SPECTROMETER

submitted by
CREOL
Center for Research and Education in Optics and Lasers
University of Central Florida
Orlando, Florida 32826

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Final Technical Report
Nonlinear Optical Spectrometer
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Due date: 1-31-97

We originally submitted a proposal to the DURIP #1 topic area to fix problems with our femtosecond continuum spectrometer and to enhance its capabilities. The original objective of this DURIP topic was to provide specialized sources and detectors for innovative spectroscopic studies, to provide data, knowledge, and insight in a broad variety of research areas of vital Air Force importance. While the specifics of how to do this were slightly changed from the original proposal, the end result is the same. We have gone a long way toward increasing the reliability and expanding the usefulness of this transient nonlinear spectroscopy system. In addition we are now obtaining some funding directly from Wright Patterson Air Force base for sensor protection research, which was one of the goals of setting up this spectrometer.

We upgraded our nonlinear spectroscopy laboratory with a new, fully solid-state femtosecond oscillator and added near infrared capabilities for the determination of nonlinear constants. This facility is designed to measure the spectrum of nonlinear absorption (NLA). From this, we determine the dispersion of the nonlinear refraction by Kramers-Kronig transformation of the NLA spectrum. We are working in partnership with researchers at Air Force laboratories in collaborative efforts toward developing a basic understanding of the nonlinear optical (NLO) interaction occuring in organic materials. The "Nonlinear Optical Spectrometer" is a major step in facilitating the generation of the database needed to attain the ultimate goal of predicting NLO properties. This system includes regeneratively amplified femtosecond pulses in a LiSAF chirped-pulse amplification scheme which are then used for time resolved nonlinear pump-probe spectroscopy. The pulse is used to create a femtosecond continuum that covers the spectral range from greater than 3 μm to shorter than 300 nm. The amplified pulses and the femtosecond continuum serve as pump and probe. This instrumentation allows rapid measurements of a material's nonlinearities, thus, a large database can be established.

The spectral range needed to adequately model organics is considerably larger than is needed for most other material systems including semiconductors, thus, explaining the need for extending our wavelength coverage. We purchased an optical multichannel analyzer with CCD with a near IR InGaAs Dual diode array and a flat-field imaging spectrometer with gratings to allow studies of this extended wavelength range.

The end goal of the research to be performed with the DURIP instrumentation is to develop new materials for nonlinear optical (NLO) applications (specifically NLO switching and sensor protection). Our contribution, in collaboration with materials scientists, is in: a) accurate measurements of fundamental NLO parameters; b) incorporation of these results into a framework of fundamental understanding; and c) utilizing these results along with materials producers to effect improvements in NLO materials. We have begun in partnership with researchers at Wright Patterson Air Force

Base (WPAFB) and other labs, collaborative efforts toward these goals. Specifically, WPAFB prepares materials which are sent to us for NLO characterization. We feed back characterization information as well as correlating with data from other materials to provide information on the relevant NLO processes.

As a result of DARPA, joint services, NSF and now DURIP sponsorship, we have extensive laboratories, techniques, and experience in place to direct toward achieving NLO materials understanding. We are confident that we can make a substantial contribution to the goal of developing improved NLO systems utilizing this Nonlinear Optical Spectrometer.

Extension of Characterization Capability Resulting From this Instrumentation.

To conduct a meaningful and accurate characterization of nonlinear materials for switching and sensor protection applications, it is necessary to apply a wide variety of measurement techniques. The new instrumentation has provided an invaluable extension of the techniques already at our disposal. The underlying theme common to all the measurement systems is that great care is taken to ensure that the instrumentation is thoroughly calibrated, as measurement of nonlinear optical properties can result in errors which are nonlinearly dependent on system uncertainties.

The "NLO Spectrometer" complements and extends the capabilities of our other characterization techniques which include: Z-scan, 2-color Z-scan, time-resolved Z-scan, time-resolved degenerate four-wave mixing, beam distortion, and pulse-probe. Specifically, the NLO Spectrometer has broadened our capabilities in the near-infrared and visible (850nm - 1.7 μm) spectral regions. Performing Z-scans at wavelengths obtainable with the laser source provide the fixed wavelength calibration of the nonlinear spectra obtained with the NLO Spectrometer.

The day-to-day operation of the NLO spectrometer system is carried out by graduate research students, at both masters and PhD level. They are students in UCF's Optical Science and Engineering degree programs, designed to produce graduates with a broad-based education in optics, as well as their particular specialization area. As CREOL is highly interdisciplinary in nature, it is likely that Physics, EE and Chemistry student will utilize the spectrometer for their research projects in the future.

Publications resulting from this instrumentation to date:

1. "Purely Refractive Transient Energy Transfer Via Stimulated Rayleigh Wing Scattering", A. Dogariu, T. Xia, D. Hagan, A. Said, E. Van Stryland, and N. Bloembergen, submitted to JOSA B in press (1997).

2. "Nonlinear Absorption and Refraction in CuCl at 532nm", A.A. Said, T. Xia, D. Hagan and E. Van Stryland, submitted to JOSA B in press (1997).

3. "Femtosecond Continuum Probe Measurements of Nonlinearities of Organic Dyes", P. Buck, A. Dogariu, D.J. Hagan and E.W. Van Stryland, Proceedings of the Conf. On Nonlinear Optical Liquids, SPIE, (Denver, 1996).

4. "Two-Beam Coupling in Liquids via Stimulated Rayliegh-Wing Scattering", A. Dogariu, T. Xia, D.J. Hagan, A.A. Said, E.W. Van Stryland and N. Bloembergen, Proceedings of the Conf. on Nonlinear Optical Liquids, SPIE, (Denver, 1996)

5. "Vis/NIR Phenomena/Devices", E. Van Stryland, Army Eye/Sensor Optical Protection Workshop, Rochester, NY, May 8-9, 1996.

6. "Continuum Pump-Probe Experiments in Organic Solutions", A. Dogariu, P. Buck, D. Hagan and E. Van Stryland, ICONO'3, Marco Island, FL, Dec. 1996.

7. "Nonlinearities of Polymethine Dyes in Liquid and Polymeric Hosts", O. Przhonska, J.H. Lim and E. Van Stryland, ICONO'3, Marco Island, FL, Dec. 1996.

6. "Femtosecond Continuum Probe Measurements of Nonlinearities of Organic Dyes", P. Buck, A. Dogariu, D.J. Hagan and E.W. Van Stryland, Conf. On Nonlinear Optical Liquids, SPIE, (Denver, 1996).